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THE PARADOX OF RESEARCH.

BY JOHN GRIER HIBBEN, PROFESSOR OF LOGIC IN PRINCETON UNIVERSITY.

BECAUSE this is a practical age, and also pre-eminently an age of extensive investigation, it might seem that the chief incentive to research would be the possibility of adding to the store of practical knowledge, and thereby increasing the general efficiency of human endeavor. But, as we read the history of scientific discovery, from the first strivings of primitive thought to the present time, we are impressed with the fact that utility is not always the mother of invention. This is the paradox which confronts us throughout the whole course of the development of scientific thought: If man interrogates nature for the purpose merely of wresting those secrets which shall minister directly to his needs or comfort, he fails to attain his end, or he attains it only in a meagre way; but if, on the contrary, he goes to nature with a desire to know her secrets for their own sake, the revelation often brings with it a wealth of knowledge which, in turn, admits of untold applications as regards the practical conveniences of life. If utility is the sole incentive to research, the results will range on a lower level; if, however, utility is forgotten in the passion to get at the heart of things for their own sake, it sometimes surprises us upon the way. And the reason of this is obvious; for utility, in all practical relations, results from the application of certain underlying principles to the concrete problems of life. The more central and comprehensive the principle, the wider will be its scope of practical application. The principles most fertile in products of utility are often most deeply hidden. They lie at the centre of things; it is only the most searching inquiry which will disclose them. The practical, however simple it may be, is always the embodiment of some theory.

The telephone, the incandescent light, the electric car—these are simply the concrete expression of a great electro-magnetic theory. The bridge swinging free and secure over the stream, self-supported by the exact calculation of its own stress and strain, is merely a set of mechanical laws objectified. If you start in your research with the sole object of solving a specific problem of practical significance merely, the result, if successful, is limited in all probability to the special end in view; on the other hand, if you set yourself the larger problem of investigating certain phenomena which have peculiarly attracted your interest for the purpose of discovering their nature and understanding their laws, then the revelation of a comprehensive principle carries with it a whole world of possibilities. A principle is not one, but many, for it admits of a multiplicity of application which knows no limit. Nature thus sets a premium upon the study of her mysteries for their own sake. There is such a thing as disinterested knowledge as well as disinterested benevolence. There is a scorn of consequence in the intellectual world as well as in the moral which tends in like manner to provoke unhesitating approval and admiration. There is an adventurous spirit in the pursuit of truth, which is under a natural compulsion to explore the undiscovered country. When the challenge of the unknown is once heard, there is a restlessness which is impatient of ignorance, a natural impulse to seek the reason of things, an instinctive curiosity which is not content to see, but which must also understand, and which is a perpetual spur to perseverance through all the exactions of laborious research. Whenever there is this inner constraint, there is a largess of spirit which has no thought of placing a patent upon the output of its brain. The glow of discovery is a sufficient reward, to which nothing can be added save the satisfaction that others share it.

It has been urged, however, that the natural origin of knowledge is to be traced to the effort which is put forth in order to satisfy some felt need. With the conscious and pressing necessities of hunting and fishing, of warfare, of cooking, of domicile and of raiment, man was quick to invent the first crude tools and weapons,—a covering for his body, a roof over his head and utensils in which he might prepare his food and which would prove indestructible when exposed to fire. Later, the pursuits of agriculture and the early beginnings of the arts of commerce and manufacture gave rise to the implements and machines representing an infinite variety of inventive skill. It is, however, a primitive age wherein knowledge arises solely in response to the demand of utility. Truly, a higher stage of civilization is reached where there exists a class, however small, which is able to devote its time and energies to the pursuit of truth for its own sake. Such a body of men has been styled the "leisure class." It is a leisure not merely from manual labor and commercial pursuits, but it is above every other thing a leisure from the servitude of utility. Such is the class of philosophers and mathematicians in the early history of Greece. Such is the scholarly class in every age, provided the appellation of "scholarly" is justly merited. The scholar, in his devotion to his subject, in his consecration to the high vocation which he follows, must be one who is emancipated from the domination of the utility idea. Then only is he a free man in the kingdom of knowledge. Bacon has said that the end of all scientific investigation is "the gathering of fruit"—that is, the turning of all discovery to some practical account. The true produce of the scholar's brain, however, is of the nature of seed rather than of fruit, and that of incalculable variety and possibility.

Although the investigator may not have sought that which is useful, yet his discoveries often admit of a direct practical application to the every-day needs and comforts of life; and so the practical value, which, throughout the whole course of his investigations was never sought and never dreamed of, may become realized, nevertheless, in full measure. The secret of nature once discovered becomes the ground of a new form of reasoning; new minds busy themselves with the practical problems which may be suggested by it. Thus in the wake of the discoverers in pure science follow the inventors. The men who were the pioneers in the field of electricity and magnetism labored with a keen interest born of a constraining love of nature, and with no thought of gain save in the discovery of that knowledge which is its own reward. And yet the work of such minds as Oersted, Ampère, Faraday and Henry opened the way to the electric telegraph and the innumerable applications of their electromagnetic discoveries, to the benefit of the race and the progress of civilization. Also, in our own day, the investigations of Hertz in Germany and of Thomson in England, incited and sustained by an interest purely scientific, have made the system of the wireless telegraphy possible. The discovery of the rays of Lenard, Becquerel and Röntgen was the result of research which was conducted in a like spirit; moreover, they have led to practical applications in the field of therapeutics and surgery which are of incalculable service; nor is the possibility of their further utility by any means exhausted. The practical value of a truth is often a kind of by-product which direct research does not reveal. The great science of modern chemistry has been built upon the foundations which were laid by the genius of Lavoisier, who brought to his labors a spirit fired by a love of nature for her own sake. However, the practical output of those labors has modified essentially every phase of our modern industrial, domestic and commercial life. The application of chemical truth to the problems of agriculture and physiology, through the brilliant work of Liebig, was possible only because of the toil of the many whose eyes were never upon the goal either of general utility or personal reward. In a quaint old writing of one of the pioneers in chemistry, Becher, called the "*Physica Subterranea,*" the author speaks of chemists as a "strange class of mortals, impelled by an almost insane impulse to seek their pleasure among smoke and vapor, soot and flame, poisons and poverty." "My kingdom," said he, "is not, however, of this world. I trust that I have got hold of my pitcher by the right handle, the true method of treating this study; for the Pseudo-chymists seek gold, but the true philosophers, science, which is more precious than gold." Such men may be nobly doomed to lives of unrequited sacrifice; but they leave to their fellows what they themselves never possessed,—the means of increased wealth, health, comfort and power.

If utility were the sole incentive to research, that most admirable of all graces, the patience of hope, would often fail; for the practical value of knowledge is slow of revelation. Knowledge, to be practically available, requires in many cases to undergo an aging process. The new wine of truth needs also the touch of time. The most beneficent ends are often so remote that they can be disclosed only after a long series of discoveries, which lead up to them by a natural sequence, but which afford in the process of their unfolding no intimation whatsoever of their ultimate utility. When the utility is not obvious in the first stages of an investigation there is need of a deeper incentive, so that research may not be abandoned in a moment of discouragement. And discouragement will come very soon if no evidence of practical results is forthcoming.

It is to be observed also that the utility of any portion of knowledge depends, in many instances, upon its combination with other portions of knowledge. Alone, it is barren. It has no utility in itself. But it may contribute certain elements which, in conjunction with others, make for utility of singular value. Darwin, in the line of his own investigations, has drawn attention to the fact that utility in most cases depends upon the co-ordination of various elements which are separately useless. It frequently happens in other fields also that the labors of many minds must be brought together in order to produce practical results of any real significance and value. The solitary toilers may not be able to discern any promise of utility in their separate labors. Their particular contribution is only a fraction, after all; and yet, nevertheless, it may prove to be an essential part of a combined whole whose resultant effects may possess practical value of a high order. The efficiency of the methods of physical science and ultimately the application of its results to practical affairs have been increased incalculably through the brilliant speculations in the field of pure mathematics of men who knew not the language of utility. Others, however, are able to combine their results in such a manner as to give a practical turn to considerations primarily theoretical.

The inventor stands at that point of advantage where many lines of discovery converge. The several independent results he is able to unite and embody in a new machine, a new method, or a new process. Many inventions appear as the outcome of collaboration; the co-workers are not always contemporary; the lapse of time alone may serve to efface their memory. Seldom known and less often appreciated, they nevertheless through their patient efforts contribute those essential elements of knowledge without which the inventor's skill would surely fail of success. We are accustomed to think of the inventor as commanding the forces of nature to do his bidding. He, however, is not dealing directly with the forces of nature, but rather with the ideas which other men have formed of these forces, which they have so interpreted that they can be made plain and be put into words and reduced to the expressions of law and formula. The inventor is not merely engaged in the task of fitting part to part of a machine; he builds with rarer material. He is building an idea which is a composite. The elements which enter into its texture are the thoughts of men.

It is to be noticed also that a mind exclusively bent upon the idea of utility necessarily narrows the range of the imagination. For it is the imagination which pictures to the inner eye of the investigator the indefinitely extending sphere of the possible,—that region of hypothesis and explanation, of underlying cause and controlling law. The area of suggestion and experiment is thus pushed beyond the actual field of vision. But, if utility is the sole end of research, the scope of imaginative inquiry is thereby narrowed. There is no comprehensive sweep of the thought, no power of divination, no compelling fancy. Whatever fails to show a face value of utility does not arrest and hold the attention. Significant facts and relations are overlooked. The byways of knowledge are left unexplored in the hot pursuit of the immediately useful. But where there is absorbed and sustained interest in a subject of research for its own sake, the imagination broods over its tasks with a delight and passion which tend to provoke the hidden truth.

In the prevailing tendency in certain quarters to direct research according to the lead of utility, there is a vicious theory of education which is being urged to-day with all the enthusiasm of a new gospel: "Teach the child that all knowledge can be disposed to some useful end. Cultivate early the habit of looking for the practical worth of everything that he learns, and let the student of later years bear constantly in mind that knowledge is power." Such is the doctrine of a bread-and-butter theory of pedagogy. But why push the child out into the current which tends to draw every one into its precipitate flow? In this age of materialistic drift, the idea of practical values and utility considerations need not be taught, nor even mentioned. The fact is, it cannot be escaped; its influence is all-pervading, inevitable. While it is undoubtedly true that the student must be interested in the subject which he is pursuing, let us not, however, confuse as some have done the two radically distinct ideas, of an interest in a subject for its own sake, and an interest in the practical utility which it may be seen to possess. It is possible, and indeed absolutely essential, in my opinion, that the student's interest should be stimulated directly by the rich material which certain subjects present, and so the thought be withdrawn, to some extent at least, from the exclusive consideration of present or future application of the knowledge which he seeks to the practical affairs of life. It is true that knowledge is power; but that should not be held out continually to the student as an alluring bait. Knowledge can compel homage and devotion without stooping to offer a bribe, or to cry the value of her wares in the street. There are, moreover, certain indirect uses of knowledge which can never be consciously in the thought of student or teacher during the actual process of instruction. They are too subtle, too far-reaching in their effects, too complex, too cumulative for any one to define, and name and put into the form of a maxim or rule. They cannot be specified and pointed to as the obvious rewards of industry in the pursuit of truth. They constitute not so much the results which knowledge can attain as the atmosphere which knowledge permanently creates,—the finer flavor of thought, the sound reason, the true judgment and the sane appreciation, which are the marks of a richly stored and accurately trained mind. He who lacks in these particulars fails to realize the full measure of his efficiency. And yet it often happens, strangely enough, that this added power in a man's life is missed simply on account of his restricted interests and his impatient haste to acquire only that kind of knowledge which may seem to him at the time to be of some obvious use and advantage in the direction of his life.

This, then, is the paradox of knowledge that he who regards knowledge as his servant is never completely master of that knowledge; but whoever regards himself as the servant of knowledge, he alone is master in the world of thought. There can be no higher standard of scholarship, or a more alluring reward of research than that which is expressed by the old Greek author, Isocrates, in his appreciation of Athens and the part which she played in the history of thought: "So far hath our city passed beyond the rest of men, both in thought and speech, that her disciples are become their teachers; and she hath made the name of the Greeks seem no longer to be the name of a race, but of knowledge. They rather are to be called Greeks who share our training than they who share our descent."

JOHN GRIER HIBBEN.